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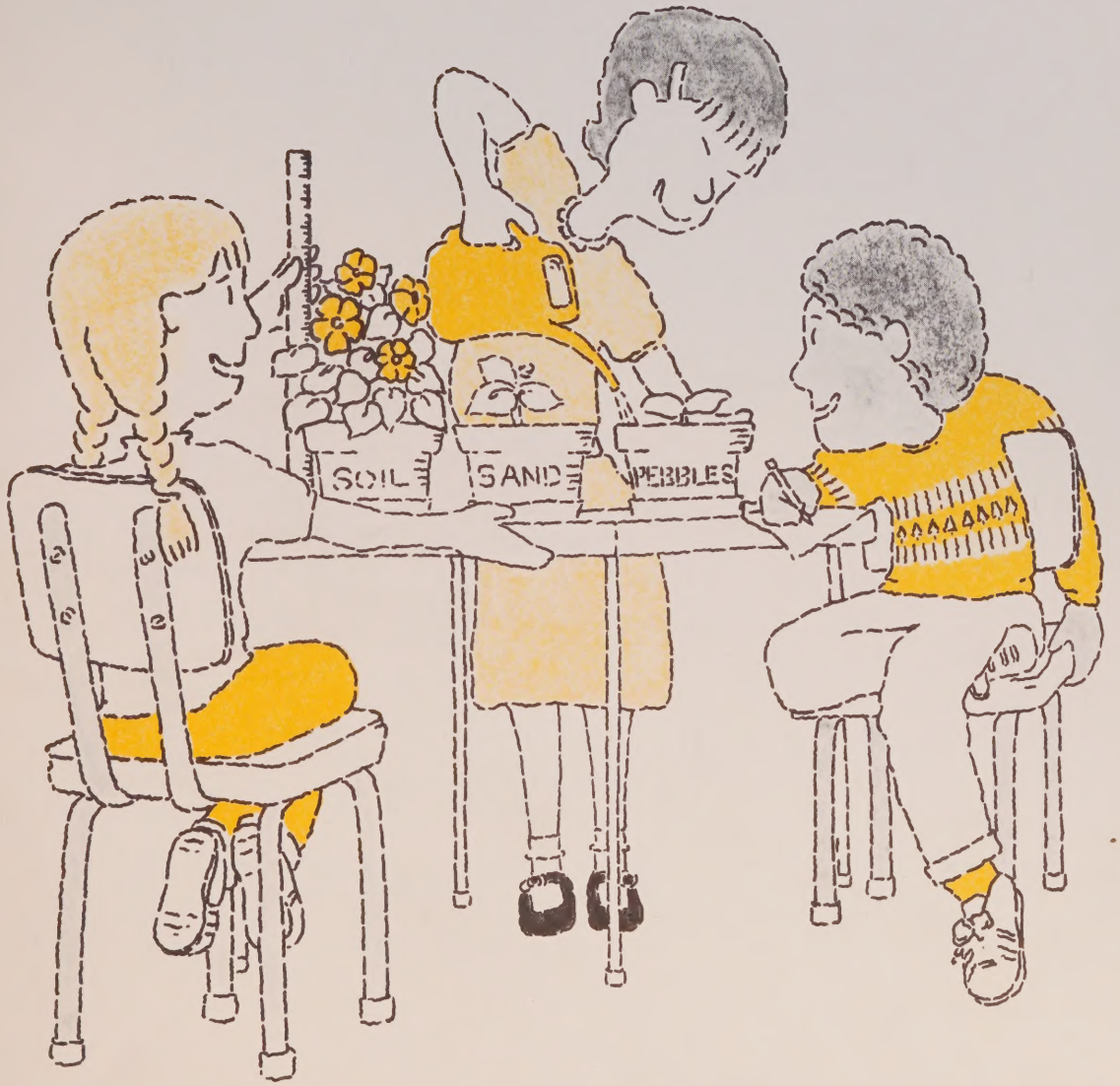
SCIENCE

IN PRIMARY AND JUNIOR EDUCATION

A STATEMENT OF DIRECTION

1986



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The Government of Ontario has committed itself to significant development in science and technology in order to establish the province as a competitor of international standing. Our education system is a key element in the attainment of this goal. It is therefore essential that science and technology be an integral part of our children's education from their earliest years.

For this reason, I am pleased to issue this statement of direction for science in Primary and Junior education, outlining a plan of action for the renewal of science education at this level in both English- and French-language schools. The plan, developed through consultation with educators and members of the science community, sets out twenty-four initiatives calling for action by the ministry, school boards, teachers, and others, in the following five categories: curriculum; support for teachers; equipment and learning materials; public awareness; and leadership, implementation, and evaluation.

The Ministry of Education is committed to the implementation of these initiatives within its own areas of responsibility, and I urge other members of the educational community to follow the ministry's example. The Government of Ontario has committed $3 million in support of this renewal. Most of these funds will be available to help school boards with their implementation activities.

In issuing this statement, I wish to reaffirm my belief in the importance of Primary and Junior education and in the need to provide children at this level with a balanced, integrated program.

Sean Conway

CONTENTS

SUMMARY OF INITIATIVES i

INTRODUCTION 1

THE PLACE OF SCIENCE IN PRIMARY AND JUNIOR EDUCATION 3
Background 3
Images of the Learner and Images of Science 4
Objectives of Primary and Junior Science Education 7

PLAN OF ACTION 9
Goals 9
Initiatives 9
- Curriculum 9
- Support for Teachers 12
- Equipment and Learning Materials 19
- Public Awareness 23
- Leadership, Implementation, and Evaluation 23

BIBLIOGRAPHY 25

ACKNOWLEDGEMENTS 27

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SUMMARY OF INITIATIVES

The plan of action set out in this statement of direction identifies twenty-four initiatives to be implemented in support of the renewal of Primary and Junior science education in both English- and French-language schools in Ontario. These are listed in this summary, within a framework of five categories. Each is discussed in more detail in the plan of action (pp.9 to 24).

CURRICULUM

1. The Ministry of Education will issue a curriculum document outlining policy and direction for the science component of a balanced and integrated program in the Primary and Junior Divisions.

2. School boards will be expected to provide teachers with curriculum support documents for science in the Primary and Junior Divisions, based on the framework set out in the provincial curriculum document.

3. The ministry will develop a Science Unit Purchase Plan in order to facilitate program development at the school board level.

4. Teachers will be expected to provide students with activities and experiences in such a way that the scientific attitudes, skills, and concepts identified in the provincial curriculum document will be developed.

SUPPORT FOR TEACHERS

5. The Ministry of Education will request the Ontario Association of Deans of Education to set up a task force to examine and advise on the specific preservice educational and training needs of teachers at the Primary and Junior levels in relation to science.

6. The ministry will offer four doctoral (or postdoctoral) fellowships to individuals choosing to specialize in science education at the Primary and/or Junior level.

7. Regulation 269 will be amended to provide for a three-session additional qualification course, Science in Primary and Junior Education.

8. The Ontario Teachers' Federation (OTF) and its affiliates, the Science Teachers' Association of Ontario (STAO), the Science Co-ordinators' and Consultants' Association of Ontario (SCCAO), the Consultants' and Co-ordinators' Association of Primary Educators (CAPE), and other scientific or educational organizations will be invited to develop an inventory of resource people for professional development in Primary and Junior science.

9. The ministry will invite the teachers' federations and other associations to designate science at the Primary and Junior levels as a priority area for professional development and to develop appropriate ways in which to express this priority to teachers.

10. The ministry will provide special grants to school boards in support of the development, testing, and reporting of innovative pilot projects in in-service teacher education in Primary and Junior science.

11. The ministry will support the development of an Ontario Elementary Science Network.

12. The ministry will publish an inventory of Ontario women in scientific and technical fields who are available to speak to children.

13. The ministry will seek the collaboration of professional organizations in hosting a major provincial conference in the spring of 1988 on science education in the Primary and Junior Divisions.

14. School boards will be requested to review their policies with respect to the provision of curriculum support personnel and to increase such support in the area of science, where possible.

15. The ministry will arrange special workshops for superintendents and principals in connection with this renewal project.

EQUIPMENT AND LEARNING MATERIALS

16. School boards will be requested to review their allocation of funds for the purchase of materials required on an ongoing basis for the effective teaching of science and to increase these allocations where possible.

17. The Ministry of Education will co-operate with the Ontario Science Centre and the Science Co-ordinators' and Consultants' Association of Ontario in setting up a provincial Science Kit Development Program.

18. The ministry's Learning Materials Development Plan and French-Language Fund will designate science at the Primary and Junior levels as a priority area.

19. TVOntario will allocate funds for the development of video material of particular use in the teaching of science in the Primary and Junior Divisions.

20. The ministry's Computers in Education Centre will ensure that software development in support of Primary and Junior science education is consistent with the policies and directions set out in the provincial curriculum document.

PUBLIC AWARENESS

21. The Ministry of Education will design special communications strategies to inform parents, school trustees, and other members of the public about this renewal process.

LEADERSHIP, IMPLEMENTATION, AND EVALUATION

22. The Ministry of Education will second a specialist in Primary and Junior science to the Centre for Primary and Junior Education for two or more years.

23. The ministry will suggest to school boards that they develop "plans of action" for the renewal of Primary and Junior science within their jurisdictions.

24. During the 1989-90 school year, the ministry will review the progress of this renewal initiative.

INTRODUCTION

In a world dominated by change, much of it in the areas of science and technology, Ontario's citizens need the best general education possible – an education aimed at excellence not only in the traditional basics of language and mathematics but also in the new basics of science and technology. Of course, the arts and humanities are as important as ever. But we must also ensure that all members of our society receive a balanced education which provides them with a basis for understanding and relating to the changing world around them.

The high school graduates of the year 2000 are in Kindergarten this year. During the next fourteen years, these individuals will be developing continuously and learning to interact with their environment in ever more complex and diverse ways. The school can facilitate this in many ways, but especially through "initiating" its students into the processes through which we as a society have come to interact with the world around us.[1] These interactive processes include the natural exploratory activities of children's play, the more structured processes of language and communication, and also those clusters of social and intellectual activity we call disciplines, of which science is one.

The problems of when and how to begin a child's initiation into each of these important aspects of cultural experience are difficult ones, to which there are no obvious answers. The importance of language is perhaps self-evident. But beyond that, who can say when young children are ready for the experience of, say, a second language, or stories from history, or science? We are not talking here about formalized content and separately timetabled lessons. Rather, we are seeking to determine the point at which activities and content drawn from the fields of science and technology can easily and profitably be woven into that integrated whole called the curriculum. The position of the Ministry of Education on this question is clear: from their youngest years, children are curious to

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1. R.S. Peters, Education as Initiation (London: Evans, 1964).

find out about their world; they explore, they inquire, they ask questions, and they enjoy the process of discovery.[2] They naturally enjoy doing science.

Despite this, finding an appropriate place for science and technology in the Primary and Junior levels of education has proven to be a challenge. It is, first and foremost, a practical challenge: how to provide concrete support for the effective teaching and learning of science in Primary and Junior classrooms. But it is also an intellectual challenge: how to describe the nature of science and science teaching in such a way as to make clear the natural complementarity of science with Primary and Junior education.

Most of this statement of direction is occupied with concrete responses to the first challenge. It addresses the areas of curriculum, support for teachers, equipment and learning materials, public awareness, and leadership, implementation, and evaluation. It sets out a concrete and practical plan of action to encourage and guide the teaching of science in the early years of school. Its goal is the extension of science education (within the general educational framework set out in The Formative Years[3] and Education in the Primary and Junior Divisions)[4] to every child in every Primary and Junior classroom in Ontario.

The other challenge facing science in the Primary and Junior Divisions results from the lack of consensus about its purpose. If the first challenge is one of overcoming the problems of practice, the second consists of clarifying the problems of rhetoric. We seem to need a fresh basis for the discussion of the place of areas of study such as science in the education of young children: the first part of this statement of direction addresses this issue with the intention of stimulating constructive discussion.

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2. See Ministry of Education, Ontario, Shared Discovery: Teaching and Learning in the Primary Years (Toronto: Ministry of Education, Ontario, 1985).

3. Ministry of Education, Ontario, Circular P1J1: The Formative Years (Toronto: Ministry of Education, Ontario, 1975).

4. Ministry of Education, Ontario, Education in the Primary and Junior Divisions (Toronto: Ministry of Education, Ontario, 1975).

THE PLACE OF SCIENCE IN PRIMARY AND JUNIOR EDUCATION

BACKGROUND

The ways in which the learner and the learning process are conceptualized have a major influence on the place accorded to all forms of knowledge, including science. Years ago, the notion of "faculty psychology" provided educators with a concept or image of learning drawn from physical training, in which the intellectual "muscles" were developed through exercise and drill. This image stressed the importance of generic skills and the three Rs.

Another image presented the mind as an empty vessel or tabula rasa (literally "blank slate") and suggested teaching methods in which children were given concepts to learn in as direct (i.e., didactic) a fashion as possible. Accordingly, knowledge of the facts and principles of science was of paramount concern to science educators.

More recently, Piaget has shown that many children are not ready to comprehend abstract concepts until they reach a certain stage of intellectual development. This conclusion has coincided with Bruner's complementary image of the child as "intellectual processor". Modern curricula and teaching methods have been strongly influenced by this image and (again) have stressed the value of acquiring intellectual process skills. The support documents Science in the Primary and Junior Divisions[5] and Shared Discovery: Teaching and Learning in the Primary Years[6] exhibit these influences in Ontario education at the present time.

However, images of the learner change with time and experience. Each image can be seen to have had value, though none is a perfect

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5. Ministry of Education, Ontario, Science in the Primary and Junior Divisions (Toronto: Ministry of Education, Ontario, 1983).

6. Shared Discovery, 1985.

representation (nor can it be). While the most recent images have been helpful in directing teachers away from excessive reliance on didactic teaching methods and towards the encouragement of "active learning", they have also had the effect of reducing the importance of the direct teaching of concepts. The assumption has been that a child acquires new concepts inductively through the proper application of inquiry skills. Research and teacher education have therefore been focused on ways in which teachers can encourage such process-skill development.

Given this context, talk of "science" in Primary and Junior education raises serious doubts in the minds of some about the compatibility of such an apparently content-centred subject with the process orientation of current thought in Primary and Junior education. It is the position of this statement, however, that images of the learner and images of science consistent with the most recent research confirm the experience of many teachers: that science can be an excellent vehicle for providing educational experiences of value to children of all ages.

IMAGES OF THE LEARNER AND IMAGES OF SCIENCE

Recent research has shown that children have their own "theories" about the world and that these (like any scientist's) guide their subsequent observations and inquiries.[7] Wynne Harlen, a specialist in elementary science education in the United Kingdom, recounts the story of a teacher who asked a group of eight-year-olds to watch carefully as two stones of different sizes were dropped into two identical jars each half full of water and to describe what differences they noticed. She hoped they would immediately mention the difference in water levels after the stones were put in. Instead the children talked about the different sizes of bubbles rising, the change in colour of the stones, and how each looked to be

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7. Ros Driver and Gaalen Erickson, "Theories in Action: Some Theoretical and Empirical Issues in the Study of Students' Conceptual Frameworks in Science", Studies in Science Education 10 (1983), pp. 37-60.

different in size when immersed. What was most obvious to the teacher, and was there to be observed by the children, was not mentioned. It was a phenomenon significant to the teacher, and her observation of it was sharpened by expectation, but the same expectations were not focusing the children's observations.[8] In other words, the use to which process skills are put is related to the conceptual framework of the user.

Of course, children's ideas may or may not coincide with those of the scientific community. Whichever is the case, children's process skills can be used to test their ideas against those of others, with the broader intention of helping children make sense of the world around them. But, as Harlen says, the most recent curriculum development projects show that "activities designed to encourage process-skill development in isolation from concept development (using 'empty' content such as black boxes or artificial problems) are as non-productive of useful learning as teaching scientific principles and generalizations by rote."[9]

It is not only the image of the learner that has suffered from oversimplication; so too has the image of science. It is regarded by some as simply a body of complex and abstract knowledge, and treated by others as a kind of "tool kit" of processes and techniques. The first image is reinforced by many science education programs at secondary school and university and is clearly quite inappropriate for the Primary and Junior Divisions. The second seems more consistent with the aims of education at this level but raises the question of whether science can add anything to a Primary or Junior student's education that cannot be achieved through other content. Science at this level, it might thus appear, is either inappropriate or redundant.

However, science is not simply a body of knowledge that can be separated from the processes by which that knowledge is developed. Nor is it merely a process, in which careful exploration of reality yields the

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8. Wynne Harlen, "Recent Developments in Primary and Lower Secondary School Science", unpublished manuscript, 1984.

9. Ibid., p.9.

generalizations that constitute scientific knowledge. Observation of the actual practice of scientists shows that when they develop hypotheses, for example, they use their accumulated scientific knowledge at the same time as they apply their process skills.

One may conclude from this research and analysis that process and content always come inextricably bound together, both in science and in education, and that any debate that seeks to categorize them as alternatives or opposites – as, for example, in the question, Are you more in favour of content or process in Primary and Junior science? – is misconceived. It also follows that students with little substantive knowledge of science cannot readily "play scientist" and are not likely to "discover" the major concepts of science through their own exploratory activities. To be sure, inquiry skills are part of the scientist's armoury (as they are also, incidentally, part of the historian's, the philosopher's, the mathematician's, and the musicologist's). But science is more than the exercise of these processes, and learning science must be more than the acquisition of the corresponding skills.

The accumulated practical experience of teachers seems to support a balanced view both of the learner and of the way in which science can best fit into Primary and Junior education. One teacher we visited during the development of this document reported that he provided an hour and a half of environmental studies at the beginning of every day (to his Grade 4 class) because so much of subsequent language arts and mathematics teaching was based on such studies. In other words, science can relate well to other areas of study. Another (Grade 1) teacher stressed the enjoyment her students derived from science: on the day we visited, they were classifying different kinds of leaves collected during a walk in a ravine near the school. This was a good example of children learning both content and process at the same time. Yet another teacher commented on the potential of science to broaden learning opportunities for children through group project work. These practical experiences (as well as many others) validate the view that a proper blend of inquiry skills and scientific concepts taught in an imaginative and relevant manner can enrich the educational experience of children of all ages.

OBJECTIVES OF PRIMARY AND JUNIOR SCIENCE EDUCATION

The major focus of science education at the Primary and Junior levels should be the science and technology in the environment of the child. This is also consistent with the principle, set out in The Formative Years, that science in the Primary and Junior Divisions be seen as a component of environmental studies.[10] At the Primary level, the concept of environment should be taken very literally, given the nature of children of this age. At the Junior level, the concept can broaden as the children begin to perceive themselves as part of a larger community. The more abstract concepts of science, which cannot be readily related to the child and his or her observations and experiences, are best left to a more systematic study of science at the Intermediate level.

Of course, children learn about science and technology from many sources, in addition to their school-based experiences. Museums, zoos, science centres, science fairs, magazines, comic books, television, radio, and family trips all complement the work of the school in helping children to understand their environment better. Such external stimuli have a part to play in the education of all children, and teachers need to be aware of the potential support that can be provided by such extracurricular or informal learning.

The essence of effective science programs at the Primary and Junior levels can be represented in the form of a triangle, shown here as Figure 1. Central to the diagram (and central to any good science program) is the student, with his or her interests, aptitudes, values, preconceptions, and beliefs about the world. Three other components form the triangle: science and technology, including the content and processes of both; the skills, attitudes, and knowledge that are the desired educational outcomes; and the social context, in which the student and science and technology coexist and interact.

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10. The Formative Years, p.22

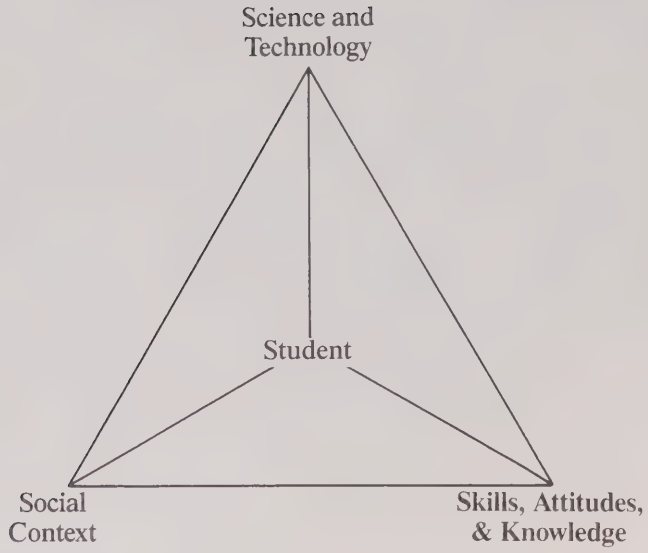

Figure 1: The Essence of Primary and Junior Science Education

In selecting content for a Primary or Junior science program, each of these three bases must be touched. Without a focus on the desired skills, attitudes, and knowledge, an activity could be fun, even scientific, but would not realize its educational potential. For example, play at a water table, the manipulation of batteries and bulbs, and a visit to the zoo can be but are not necessarily educationally significant experiences. Without an appreciation of the scientific or technological content of an activity, students could be learning something but failing to gain the maximum benefit from the experience. Without a social context, science can lack meaning or relevance for children. When opportunities for learning are selected from their immediate environment, children discover that science and technology are part of their world, a world which they can understand and interact with. Without such a context, the science content can be abstract and remote from the children and can contribute to a sense of alienation. Such a lack of social relevance may, for example, be a contributing factor in the early loss of interest in science among girls. By contrast, experiences that enable children to appreciate, understand, and relate to the science and technology in the world around them can contribute to their enjoyment of science, their development as individuals, and their ability to participate fully in an increasingly technological society.

PLAN OF ACTION

GOALS

The renewal of science education will take place in both English- and French-language schools with two goals in mind – relevance and excellence. Relevance can be ensured if the needs, interests, and abilities of the child remain central to the development of curriculum and the translation of curriculum plans into classroom realities. Excellence can be achieved if we learn from what has already proven to be excellent – the best existing science programs, the best classroom practices, the best approaches to in-service education, the best learning materials, and so forth. The plan of action set out here is based on the successful experiences and ideas of science educators and Primary and Junior specialists from all parts of the province.

INITIATIVES

Curriculum

During the past decade, many school boards have developed science (or environmental studies) programs for use in their jurisdictions. These are all based on The Formative Years but, because science content is not specified in that policy document, a considerable degree of variation exists in the content and structure of the individual programs.

There is no general agreement about what particular selection of science content is appropriate for the Primary and Junior years. For this reason, some have argued that the selection of content is best left entirely to the discretion of the teacher. However, several practical considerations suggest that the time has come to consider the value of a more specific provincial program.

Firstly, many teachers have little formal background in science and find it difficult to make decisions about science content unaided. This is one

of the reasons that school boards have developed their own programs, drawing on the experience and expertise of science specialists as well as of other teachers with confidence in the field.

Secondly, the lack of agreement about program content across the province has resulted in the general lack of published resource materials in support of teachers' or boards' programs. This applies not only to formal textbooks but also to other learning materials for students, including kits of equipment, video material, and software.

For these and other reasons, the Ministry of Education will issue a curriculum document outlining policy and direction for the science component of a balanced and integrated program in the Primary and Junior Divisions. This document will be prepared during the 1986-87 school year using established ministry procedures for curriculum policy development. The process will therefore involve consultation and writing teams made up of classroom teachers and members of support groups from both divisions from across the province.

The curriculum document will identify, for each division, those attitudes, skills, and concepts that should be developed through the science component of a child's program. In preparing this document, consideration will be given to maintaining a balance between the major areas of science and technology that both girls and boys encounter in their daily lives. These include:

- life science (including the study of plants, animals, ecology, health, and agriculture);
- physical science (including the study of matter, energy, and time);
- earth and space science (including the study of rocks and minerals, weather, and astronomy);
- technological science (including the study of simple machines and engines, flight, clocks, and computers).

The document will also include advice on ways of encouraging a positive interest in science among students who traditionally have been inclined to avoid the subject. For example, girls in our society have sometimes been

led to think of science and technology as having little direct connection with their lives and little bearing on their choice of career. Francophones too have often pursued the arts and humanities rather than the sciences. The ministry will ensure that its curriculum document contains suggestions for boards and teachers on strategies to encourage these learners. In addition, the document will discuss such topics as the special needs of exceptional students, specific safety considerations relating to science activities, and the support role of the Ontario Assessment Instrument Pool (OAIP) for Junior Division science.

School boards will be expected to provide teachers with curriculum support documents for science in the Primary and Junior Divisions, based on the framework set out in the provincial curriculum document. A number of school boards have developed units designed to support teachers' science programs. In order to assist all boards in their program development, the ministry will develop two inventories of these units (one in English, the other in French) cross-referenced to the new curriculum document. These will be entered in ONTERIS and will be available to all boards in the province. In order to assist boards who wish to purchase these units, the ministry will develop a Science Unit Purchase Plan. Special arrangements will be made through the Centre Franco-Ontarien de ressources pédagogiques for the sharing of French-language units.

Boards whose units are purchased in this way will be encouraged to extend their development work so that more units can be made available. Special efforts will be made to facilitate the development of more French-language units.

Teachers will be expected to provide students with activities and experiences in such a way that the scientific attitudes, skills, and concepts identified in the provincial curriculum document will be developed. This statement of direction strongly endorses the principle of a balanced and integrated program. The way that this is translated into practice is clearly a function of the age of the children and the teacher's overall program structure. However, it is the teacher's responsibility to allocate sufficient time to ensure that these expectations can be met.

Support for Teachers

However appropriately selected and clearly set out the science program may be, it is of little value unless teachers are prepared and motivated to incorporate it into their curriculum. While teachers in the schools of Ontario are amongst the best qualified and experienced in the world, many were trained at a time when science was not seen as having the importance it has today. Furthermore, science has been given a relatively low priority in Primary and Junior education. It is therefore important that additional support for the teaching of science at the Primary and Junior levels be put in place.

In this statement of direction, support for teachers is considered to include teacher training, both preservice and in-service, and the maintenance of an environment that encourages the teaching of science.

1. Teacher education

It is evident that effective science teaching at the Primary and Junior levels requires teachers with appropriate background education and training. In this regard, the importance of both preservice and in-service education must be considered. In-service education is important because the majority of those who will teach science at the Primary and Junior levels during the next decade are already in the classroom. Preservice education is important because the number of new teachers entering the profession each year is expected to increase steadily.

a) Preservice teacher education

Defining the general educational and professional training needs of those who will teach in elementary schools is a complex task, and structuring a university program to meet those needs is no less difficult. Teachers need not only a knowledge and understanding of children's developmental needs and styles of learning, but also a basic grounding in all areas of the school curriculum. They must learn effective strategies for teaching each area of study in an integrated program.

Teacher education institutions have the lead role in this area but school systems and other university faculties can also play important parts. Accordingly, a special review is currently under way to determine future directions for the development of teacher education in Ontario.

The specific needs of elementary teachers in relation to science will be addressed by this general review. In addition, the Ministry of Education will request the Ontario Association of Deans of Education to set up a task force to examine and advise on the specific preservice educational and training needs of teachers at the Primary and Junior levels in relation to science. This task force should comprise both Anglophone and Francophone teachers, Primary and Junior education specialists, and representatives of university faculties of arts and science as well as education. The task force will also be asked to suggest ways in which teacher training programs should prepare teachers to interest and encourage girls in science-related activities and learning. The findings and recommendations of this task force will be of value to the universities and the Ministries of Education and of Colleges and Universities, as these institutions develop policies and programs relating to teachers' needs in the future.

One of the problems currently faced by faculties of education (both in Ontario and throughout Canada) is a serious shortage of suitably qualified persons to teach, conduct research, and provide leadership in the areas of science education at the elementary school level. Few science education faculty have elementary school backgrounds or research interests and, in Ontario, there are no graduate programs with a specific focus on the Primary or Junior level. In order to encourage the development of more academic specialists in this area, the ministry will offer four doctoral (or postdoctoral) fellowships to individuals choosing to specialize in science education at the Primary and/or Junior level. These fellowships will be available for study at the Ontario Institute for Studies in Education (OISE), at the University of Ottawa, or at universities outside Ontario during the 1987-88 and 1988-89 academic years.

b) In-service teacher education

This is the area in which, by common consent, most of the effort towards the renewal of science education at the Primary and Junior levels is required. Teachers at the Primary and Junior levels often do not feel "comfortable" either with science or with the thought of teaching science. The major focus of in-service education, therefore, should be the raising of this "comfort level" through appropriate science-related experiences.

Several recent reports have discussed the need to increase the effectiveness of in-service teacher education. Ministry reviews,[11] the Science Council of Canada's national study of science education,[12] and most recently, a general survey of the educational literature,[13] all offer similar suggestions for more effective approaches. These include involving teachers in program planning, relating in-service education to general plans for program renewal, and providing the time, follow-through, and opportunities for feedback and analysis required if changes in classroom behaviour are to result. In particular, the literature survey stresses the importance of collegiality and the need to respect teachers' professionalism.[14] While further analysis of these important matters is beyond the scope of this statement, those responsible for in-service teacher education programs are urged to study these and other reports carefully.

In the specific situation of science at the Primary and Junior levels, it is apparent that the needs of teachers around the province are quite diverse. Some have indicated that full-length courses leading to

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11. e.g., Ministry of Education, Ontario, "Professional Development Practices", Provincial Review Report no. 6 (Toronto: Ministry of Education, Ontario, 1985).

12. Science Council of Canada, Science for Every Student: Educating Canadians for Tomorrow's World, Report No. 36 (Ottawa: Science Council of Canada, 1984), pp. 53-58.

13. Thomas L. Russell, "Literature Survey: In-service Education", paper for the Provincial Teacher Education Review, 1986, pp. 9-15.

14. Ibid., p. 14.

additional qualifications would be appreciated. Others have enjoyed "mini-courses" of twenty to thirty hours' duration (either in a continuous block of time during the summer or as a series of weekly sessions during the school year). Still others have found various innovative ways in which to combine the professional development opportunities provided during school hours with teacher exchanges, team-teaching situations, and the assistance of school board consultants.

Overall, it is clear that there is no one ideal format for the organization of in-service teacher education; it is also clear that new approaches – individualized, school-based, and long-term – need to be attempted. Furthermore, it would appear that the current renewal of science education at the Primary and Junior levels provides the opportunity to initiate such approaches. While the co-ordination of an individual teacher's in-service education must take place at the local level, resources for in-service education may be drawn from a wide variety of sources. Although the ministry cannot determine the professional needs of an individual teacher, it can ensure that as wide an array of learning opportunities as possible be provided. The following series of actions has therefore been planned.

Regulation 269 will be amended to provide for a three-session additional qualification course, Science in Primary and Junior Education. In offering this course, which will be based on the new provincial curriculum document, teacher education institutions will be encouraged to recognize the broad geographical spread of the potential enrollees and to develop appropriately innovative approaches for the course's delivery. For example, the course might be presented through modules or mini-courses, or offered in conjunction with individual school boards (or groups of boards) within the institution's catchment area. Where numbers warrant, there should be separate sections for Primary teachers and Junior teachers, in recognition of their different needs.

Teachers also share the responsibility for their own professional development. The Ontario Teachers' Federation (OTF) and its affiliates, the Science Teachers' Association of Ontario (STAO), the Science

Co-ordinators' and Consultants' Association of Ontario (SCCAO), the Consultants' and Co-ordinators' Association of Primary Educators (CAPE), and other scientific or educational organizations will be invited to develop an inventory of resource people for professional development in Primary and Junior science.

There are many teachers, consultants, co-ordinators, and others in the province with successful experience in the teaching of science at the Primary and Junior levels. However, the teachers' federations that sponsor professional development opportunities for teachers at the local level have few resource people listed for Primary and Junior science. By contrast, the subject associations have some expertise in the area but lack the resources and administrative machinery. The collaboration of teachers' federations and other associations in this effort will thus be of major significance.

In addition, the ministry will invite the teachers' federations and other associations to designate science at the Primary and Junior levels as a priority area for professional development and to develop appropriate ways in which to express this priority to teachers. These might include special conferences or regional workshops, or special issues of magazines or other published material.

The ministry will provide special grants to school boards in support of the development, testing, and reporting of innovative pilot projects in in-service teacher education in Primary and Junior science. It should be noted that this does not represent a change of policy with regard to responsibility for the provision of in-service teacher education in general. Through a limited number of grants in support of pilot projects in various parts of the province, the ministry intends to stimulate the development of new approaches to the in-service education of teachers at the Primary and Junior levels, emphasizing science education. Each project will be carefully monitored and the degree to which the objectives have been achieved will be assessed. Reports on the projects will be disseminated as widely as possible.

Competitions for grants will be held early in 1987 for the 1987-88 school year and again in 1988 for the 1988-89 school year. Application procedures and criteria for the awards will be announced as soon as possible. Grants will not exceed 50 per cent of the costs of each project. School boards will therefore be encouraged to collaborate with each other, with universities, or with other organizations in the development of program proposals.

2. Maintaining a supportive environment

As much as teacher education can enable a teacher to acquire new knowledge and skills, this expertise cannot become a regular feature of the classroom unless there is a climate of support for change. The most important source of this support for the classroom teacher is obviously the school principal, but initiatives at the provincial and school board levels can also be of value.

a) Provincial level

The Science Council of Canada study found that teachers at the Primary and Junior levels often felt isolated,[15] and those who are trying to incorporate science into their programs may feel especially so. In response to this situation, the ministry will support the development of an Ontario Elementary Science Network. The idea of a network for elementary science began in British Columbia with the work of the Association for the Promotion and Advancement of Science Education and has since spread to the other western provinces.

The immediate effect of Ontario's participation in the network will be that every teacher in the province at the Primary and Junior levels will receive a free copy of ESN News, a newsletter published four times each school year which focuses on the teaching of science at the elementary level. In addition, by sending their names to a provincial network

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15. Science Council of Canada, op.cit.

co-ordinator, teachers will be able to enrol as individual members of the network and exchange information directly with other members. A directory of Ontario network members will be developed. ESN News will therefore provide teachers with opportunities for sharing ideas with teachers both in Ontario and in other provinces.

Role models can play a very important part in encouraging girls and young women to develop positive attitudes towards science and science-related careers. There are many Canadian women working in scientific and technical fields and an inventory of those available to speak to children has been developed. The ministry will publish this inventory and distribute copies to all schools in the province.

The professional conference is another means of support for teachers which can be provided at the provincial level. Such conferences can also bring the best of current research and practical experience from across Canada and other countries to the attention of Ontario educators. Accordingly, the ministry will seek the collaboration of professional organizations in hosting a major provincial conference in the spring of 1988 on science education in the Primary and Junior Divisions.

b) School board level

A common feature of school boards in which significant progress has been made in the area of Primary and Junior science is the presence of a board science specialist. Such a co-ordinator or consultant can show leadership in developing and implementing the board's plans for science programs and can provide significant support for teachers in the task of implementing those plans.

In recent years, some boards have seen fit to reduce the number of such specialist personnel. During the present period of special concern for science at the Primary and Junior levels, school boards will be requested to review their policies with respect to the provision of curriculum support personnel and to increase such support in the area of science, where possible. Attention should also be given to the needs of Francophone teachers.

c) School level

Elementary school principals are curriculum leaders in their schools: they will be key individuals in this renewal process. Research has shown that a successful science program is most likely to be found in a school where the principal is well-informed and supportive.[16] To this end, the ministry will arrange special workshops for superintendents and principals in connection with this renewal project.

Equipment and Learning Materials

1. Equipment for teaching science

A feature of exemplary science education, especially at the Primary and Junior levels, is extensive "hands-on" activity by students. Indeed, such activity is fundamental to a young child's learning. Some materials, such as sand and water tables, blocks, and aquaria, should be available for the use of students on an ongoing basis. School boards will be requested to review their allocation of funds for the purchase of materials required on an ongoing basis for the effective teaching of science and to increase these allocations where possible.

Because the preparation of materials for science teaching requires planning, time, and some expertise, "lack of materials" is often cited as a reason for the absence of a science component in a school program. Many materials, however, are required only for specific units of study. Several of the larger boards in the province have therefore developed science kit loan programs, through which teachers can order a prepared kit of material for a unit of study from a central resource centre. After the unit has been completed, the kit is returned, checked, and restocked

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16. For example, see Michael Fullan, The Meaning of Educational Change (Toronto: OISE Press, 1982); Kenneth Leithwood and Debbie Montgomery, "The Role of the Elementary School Principal in Program Improvement", Review of Educational Research 52 (1982), pp. 309-39; and the publications of a recent project of the (American) National Science Teachers' Association, Promoting Science Among Elementary School Principals (see Bibliography for publication titles).

with consumables before being sent out again. Those boards that have developed such kit programs report a high rate of utilization by teachers and a more effective implementation of their science programs.

Three types of resource are required for the setting-up and operation of an effective kit program. Firstly, an individual with organizational ability and with science teaching experience with young learners is needed to design and test the kits. (All the kit programs established to date have been in boards with full-time science co-ordinators.) Secondly, the board must be prepared to make the financial investment in materials for the kits. This cost will vary according to the number of different kits (typically, each unit in the science program would have its own kit), the number of schools within the board's jurisdiction, and the cost of materials for each kit (a single kit might cost from $50 to $250 and be used by six teachers in the course of a year). Such an investment can naturally be spread over a period of years. The third requirement of an effective kit program is a procedure for the storage and maintenance of kits and for their distribution to schools. Arrangements for this will vary according to the geography of the board and the facilities and support staff available.

The ministry believes that the kit concept is a useful one and would like to see it extended. To this end, the ministry will co-operate with the Ontario Science Centre and the Science Coordinators' and Consultants' Association of Ontario (SCCAO) in setting up a provincial Science Kit Development Program. This program will build on the successful experience of those boards that have developed kits. The Ontario Science Centre will develop kits for the themes identified in the new science curriculum document. These kits will be field-tested with students and teachers before being marketed. SCCAO will be asked to develop a guide for school boards on the successful setting-up and operation of a kit loan system for schools.

Boards will benefit from this program in two ways. Firstly, a booklet on how to operate a successful kit loan system, together with listings of all the materials contained in the Ontario Science Centre kits, will be available (free of charge) to boards wishing to develop their own kits.

Secondly, complete kits will be available and marketed at reasonable cost by the Science Centre (or by companies licensed by the Science Centre for this purpose). The Science Unit Purchase Plan will assist boards with the purchase of kits.

2. Learning materials: Print

At present, Circular 14 lists few learning materials for science at the Primary and Junior levels. Part of the reason for this is that the diversity of content around the province has acted as a disincentive to publishers developing textbooks or other student-oriented material. The publication of a provincial curriculum document for science in the Primary and Junior Divisions is expected to change this situation. Publishers will be invited to propose new materials, if possible in formats other than formal textbooks, for approval for Circular 14.

To stimulate the development of new learning materials in this area, the ministry's Learning Materials Development Plan and French-Language Fund will designate science at the Primary and Junior levels as a priority area. The particular needs of French immersion classes will be studied further.

3. Learning materials: Video

TVOntario has several science series of relevance to the Primary and Junior levels. For example, Science Alliance, a series which has been available for several years, is oriented towards children at the Junior level. A new series, Take a Look, oriented more towards children in the Primary Division, will be available in the fall of 1986. This new series exemplifies particularly well the philosophy of science in Primary and Junior education embodied in this statement.

In addition, the Ministry of Education has established a close link with TVOntario, with the aim of establishing future programming priorities in relation to school curricula. TVOntario has recently been awarded

additional funds to support the development of curriculum-related material in the fields of science and technology. TVOntario will allocate a portion of these funds for the development of video material of particular use in the teaching of science in the Primary and Junior Divisions.

4. Learning materials: Computer software

The ministry's Computers in Education Centre has initiated a special project to determine the ways in which computers should be used for science at the elementary school level and to define specific needs for software development. The resulting recommendations will guide the Centre's development plans. The Centre will ensure that software development in support of Primary and Junior science education is consistent with the policies and directions set out in the provincial curriculum document.

Preliminary findings indicate that the computer can play at least two important roles in Primary and Junior science education, to complement and enhance children's own hands-on activities. Firstly, simulation and problem-solving software can extend the range of phenomena that a young child can investigate interactively. Secondly, software tools incorporating word processing, data-base management, spread sheets, and graphics can be used by children to record, store, analyse, display, and report scientific data that they themselves have collected. By thus using the computer as scientists do, children can develop valuable scientific skills and attitudes.

Two final points must be made. The first is that equipment and materials, however well-designed, only complement an experienced and well-prepared teacher. The purchase of materials without the provision of corresponding in-service education for teachers is a poor investment. The second point concerns the use of these resource materials. Effective science teaching promotes active learning: students participate in science, they do not just read about it. Printed, video, and software materials can help students to understand the applications of science in the world around them and to become aware of phenomena beyond the

scope of their own direct inquiry. But the thrill of seeing the results of their own activities can only come from a hands-on approach. A blend of all these resources is therefore needed.

Public Awareness

The renewal of science in the Primary and Junior Divisions requires a clearly defined program, teachers who are trained and motivated, and resource materials and equipment for student use. It also requires public interest, understanding, and support. In particular, parents and trustees are influential in the renewal process. It is important, therefore, that these groups be adequately informed about the reasons for seeking a renewal at this time and that they be invited to take an active interest in its implementation.

The Ministry of Education will design special communications strategies to inform parents, school trustees, and other members of the public about this renewal process. It is expected that short videotapes, video clips for broadcast purposes, printed brochures, and other materials will be made available in order to familiarize local groups with the renewal program.

This public awareness program is also a means of highlighting the particular needs of girls in relation to science. While the general renewal of science programs in the Primary and Junior Divisions will benefit both girls and boys, it cannot by itself eradicate the unequal participation in science-related careers that stems from sex-role stereotyping in society. The public awareness program will remind teachers, parents, and students of their shared responsibility of ensuring that both girls and boys aspire to the full range of careers.

Leadership, Implementation, and Evaluation

In order to support the renewal process at the provincial level, the Ministry of Education will second a specialist in Primary and Junior science to the Centre for Primary and Junior Education for two or more

years. This individual will lead the curriculum development process, participate in the awarding of grants for innovative in-service education projects, assist in the establishment of the Elementary Science Network in the province, co-operate with ministry regional offices in the organization of workshops for school administrators, and collaborate with the Ontario Science Centre in the development of the kit program. Special provisions will also be made in order to meet the needs of the French-language educational community.

Regular planning for Primary and Junior education should include planning for science. However, in order to implement this special initiative, the ministry will suggest to school boards that they develop "plans of action" for the renewal of Primary and Junior science within their jurisdictions. Such plans would detail the allocation of specialist personnel, the development or purchase of curriculum units (teachers' guides), the in-service education initiatives for teachers in this area, the development or acquisition of science kits and other learning materials, and the activities designed to promote public awareness (especially amongst parents and trustees). Ministry regional office staff will be available to review these plans on request.

During the 1989-90 school year, the ministry will review the progress of this renewal initiative. Prior to that time, the ministry will hold discussions with the teachers' federations, other professional associations, and researchers in the fields of implementation and evaluation, so that appropriate indicators of the effects of the renewal can be defined. A description of these indicators will be circulated to boards well in advance of the actual review.

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